Resilient Sustainable Built Environments

Subjects: Green & Sustainable Science & Technology

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Achieving sustainability objectives such as the SDGs and climate change targets, will require a more rapid and radical transformation of built environments. The onset of climate change also means that built environments face unprecedented environmental hazards, including hotter temperatures, droughts, storms, and flooding. However, sustainability and resilience objectives often appear to be in conflict. Sustainability is concerned with transformation to achieve a better futures and efficiencies while resilience focuses on the maintenance of existing systems and reliability. A synthesis between these objectives needs to be achieved to enable efficient sustainable development

resilient sustainability | sustainable built environments | resilient sustainable built environments | RESUME | Resilient sustainability measurement and evaulation | building rating tools | resilience measurement and evaluation | infrastructure resilience

1. Introduction

The scale and nature of climate change issues require a much more rapid and radical change built environments [1][2][3][4][5]. Existing and new built environments need to be have characteristics that enable sustainability such as increased densities, mixed-use neighbourhoods, renewable energy systems and products and services based on the circular economy.

Climate change also means that built environments must adapt to new and unpredictable weather conditions including extreme heat, storms and flooding[6][7][8][9][10]. This will require characteristics which support resilience such as increased insulation and cooling systems, strengthened structures, and raised floors and flood walls.

2. Conflicts between Resilience and Sustainability

These pressures raise several questions. Can more built environments be created which are both more sustainable and more resilient? In developing more sustainable environments, can resilience principles be drawn on to address climate change? How can the apparent conflicts between these approaches be managed?

3. Resilient Sustainability

Achieving sustainable development and climate change targets will require the integration of sustainability and resilience. This integration can be referred to as resilient sustainable. Resilient sustainability is described by López-Ridaura et al., in the following way:

"..the degree to which a system is sustainable will depend on its capabilities to produce…, a specific combination of goods and services that satisfies a set of goals ..even when facing..'extreme' …variations" [11].

Thus, in built environments, resilient sustainability can be understood as the development of built environments which enable sustainability, while ensuring that the functionality of these environments is maintained and enhanced through a focus on resilience

Resilience in urban and built environments has been addressed by the City Resilience Index developed by Arup, the City Resilience Profiling Tool developed by UN-Habitat and disaster resilience indicators developed by ISO as well as cities[12][13][14][15][16].

These frameworks focus on the recovery and adaptation of existing engineering and ecological systems[17]. They do not include transformation and social change [18] . Resilience frameworks are also selected for their ability to reinforce and strengthen particular sectors [19]. Thus, for instance, some frameworks will address flooding, while others will deal with issues such as the COVID-19 pandemic [17]. The RESUME framework focuses on achieving resilient sustainable development.

4. Resilient Sustainability Measurement and Evaluation (RESUME) Framework

The Resilient Sustainability Measurement and Evaluation (RESUME) framework aims to ensure that sustainable development trajectories are maintained. It combines sustainability objectives and resilience principles to propose resilient sustainable built environment capabilities and characteristics[20]. These are shown in the table below.

Sustainability Criteria	**Required performance**	**Resilient Sustainable Built environment capabilities and characteristics**
Food: Measured in type and amount of food consumed.	Occupants can meet their nutritional requirements through affordable, low ecological footprint means.	Local availability of low ecological footprint foods. This would include local retail and food markets Ability to produce low ecological footprint food. This includes urban

		agriculture, and intensive farming close to urban areas.
Shelter: Measured in size, utilization and energy consumption.	Occupants can meet shelter requirements through affordable, low ecological footprint means.	Appropriately sized, resource-efficient accommodation. This includes higher density buildings in mixed use developments with highly efficient energy, water and waste systems as well as with renewable energy systems
Mobility: Measured in the type of transport used and distances travelled.	Occupants can access daily requirements using low ecological footprint means.	Daily requirements are accessible within walking distance. This includes mixed use development that enable user to walk to facilities such as workplaces and schools that are used on a daily basis. Access to local public transport.
Goods: Measured in type and quantity consumed.	Occupants can access required goods through affordable, low ecological footprint means.	Appropriate goods available locally. An example includes timber furniture nearby manufactured from timber that is grown locally. Facilities to support efficient usage / shared use of goods. Examples include tool and equipment hire and libraries.
Services: Measured in type and quantity consumed.	Occupants can access required services through affordable, low ecological footprint means.	Appropriate services are available locally. This includes services such as personal and health care services provided by local practitioners. Facilities to support efficient usage of services. This includes the provision of affordable workplaces which enable diverse local services to be provided.

Health: A long healthy life, measured by life expectancy at birth.	Occupants can access facilities required for health.	Access to sports, health, and leisure facilities such as parks, running tracks and gyms. Access to healthy food and clean water. No local hazards such as violent crime and pollution.
Knowledge: measured by the adult literacy rate and combined primary, secondary, and tertiary gross enrolment ratio.	Occupants can access facilities required for learning and education.	Access to primary, secondary, tertiary and ongoing learning facilities. This includes access to high speed internet and evening and online courses.
Standard of Living: A a decent standard of living, as measure by the GDP per capital in purchasing power parity (PPP) in terms of US dollars.	Occupants can access opportunities to enable a decent standard of living.	Access to employment opportunities. Self-employment opportunities including access to low cost rental units and opportunities to provide local products and services. Access to support for small enterprise development including technical support, advice, affordable rental facilities and finance.

5. Discussion

The RESUME tool includes criteria that measure these resilient sustainable built environment capabilities and characteristics and can be used to evaluate urban areas and has been used to assess informal settlements in South Africa.

The RESUME approach differs from other urban resilience frameworks in two distinct ways.

First, instead of a broad focus on the recovery of engineering and ecological systems, it aims to develop and maintain more sustainable systems. Thus, if climate change damaged an unsustainable system, its recovery in its current form would not be prioritized and instead, a more sustainable adapation or a replacement with a more sustainable system would be prioritised.

Second, change and transformation are integral to the methodology. Rather than reinforcing the status quo, it seeks to promote change and transformation that create more sustainable resilient systems.

6. Conclusion

By combining sustainability and resilience, the concept of resilient sustainability and the RESUME methodology provides a way to address sustainability and resilience simultaneously. Efficiencies generated by this synthesis approach are very valuable given the nature and scale of climate change and sustainable development challenges and the limited resources available to address this.

7. Acknowledgements

This paper draws on a paper by Gibberd which develops the concept of resilient sustainability and applies it through the RESUME framework to assess neighbourhoods[20].

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